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Regional Prospecting for Iron Ores in Bahariya Oasis-El Faiyum area, Egypt, Using Landsat Satellite Images

(Part I)

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ABSTRACT

Based on deep theoretical and practical considerations of iron deposition in the northern and central Western Desert of Egypt, an area exceeding 100,000 km^2 is chosen for regional iron ore prospecting. This area has been called Bahariya Oasis - El-Faiyum area and it extends from the west of Bahariya and Farafra Oases eastwards to the Nile Valley. The most modern techniques of regional prospecting of iron deposition have been applied under the prevailing conditions in this area, especially the interpretation of LANDSAT satellite images and quantitative structural analysis.

New discoveries of iron occurrences have been registered as a result of the present prospecting work, and the conditions of the already known iron ore deposits and occurrences are regionally connected and verified. Several localities are recommended for more detailed prospecting and exploration for iron ore deposits, which are arranged according to their priorities.

CHAPTER I

STRUCTURAL ELEMENTS OF IRON DEPOSITION

Structural Interpretation of LANDSAT Images Applied to Iron Deposition

The construction of geological, structural and drainage maps for Bahariya Oasis-El Faiyum area from LANDSAT satellite images has led to the deciphering of the regional geological picture of this area. The interpretation of the satellite images has been directed mainly towards the deciphering of the regional conditions of iron deposition, and their application towards the discovery of new iron occurrences or the understanding of the status of the already known iron ore deposits and occurrences.

Two major structural elements are found in the investigated area, namely, folding and fracturing including faulting. It has been found that the iron ore deposition is not primarily controlled by fracturing. Accordingly, although the fracture systems are drawn on the enclosed structural maps, they are not analyzed in this work which is devoted primarily to the positive elements of iron prospecting, and will be given in a subsequent work. Iron ore deposition, however, was found to be related to folding and unconformity surfaces. Of

special importance in this respect is the Laramide diastrophism which was initiated in the Late Cretaceous and continued into the Paleogene which played a special role in the deposition of iron ores in combination with the climatic conditions prevailing during the Late Cretaceous and which has been proved to be tropical to subtropical (El Shazly and Krs, 1973).

The known iron ore deposits in Northern Bahariya Oasis locality - enclosing El Gedida, Gebel Ghorabi and El Harra - have been found on LANDSAT images to be mostly located on crenulations representing hinge areas of relatively meso or macro folds with axial trace of nearly NE-SW trend.

In addition, the already known iron occurrence of El Heiz in the Central Bahariya Oasis locality are, in the same manner, located on crenulations representing hinge areas of relatively meso or macro folds. However, the final traces of these folds possess variable trends ranging from NW-SE to NNW-SSE directions. At least two generations of deformation have acted on the rocks of the previously mentioned localities, as well as, the mapped Bahariya Oasis-El Faiyum area.

In addition to the two known localities of iron deposition, three more localities of comparable tectonic setting - namely Gebel

Qalamun Locality, Qaret Had El Bahr locality and Southern Bahariya Oasis locality -- have been given particular attention in the field work and they show the presence of iron occurrences in the exposed rocks.

The registration of favorable structures on the satellite images in the following localities, namely, the extension of Northern Bahariya Oasis locality, Ghard Ghorabi locality, West El Faiyum locality and West Giza locality, leads to the recommendation of these localities for subsurface prospecting of iron ore deposits, although surface exposures of iron occurrences have not been noted during the field work carried out so far in the investigated Bahariya Oasis-El Faiyum area. In the mentioned localities the rocks belonging to the Late Cretaceous and the lower formation of the Middle Eocene rocks are not normally outcropping in the surface and they are usually covered with later Middle Eocene, Late Eocene and Oligocene rocks.

Field Structural Verification of Iron Deposition

Introduction

Two systems of minor folds are associated with the already known and the newly discovered iron occurrences in the investigated Bahariya Oasis-El Faiyum area. These occurrences are Northern Bahariya Oasis, Central Bahariya Oasis, Southern Bahariya Oasis, Qaret Had El Bahr and Gebel Qalamun. The structural field data are tested if two of minor fold systems or one of them indicate corresponding major folds, or they are just local inhomogenities.

A new technique is applied for treating the field data to determine the major structures which could not be fully investigated in outcrops, as well as their geometrical elements. This technique is based on viewing the linear structures and the normals of the planar structures as vectors of a unit magnitude each (Ramsay, 1967 & Koch 1971). The vectors are expressed in terms of direction cosines p,q and r related to the cooridnate axes x,y and z which are coinciding with the E-W and N-S geographic directions, and the vertical, respectively. This method is more accurate than the current graphical methods, as the former avoids the drawing errors, and gives results which cannot be elucidated on the same detailed level in the diagrams.

Structural Test of Field Data in Northern Bahariya Oasis Locality

To carry out the test, the orientation data are assumed to be disposed on a surface of a cone; then it is proceeded to determine the orientation of the cone axis and the amount of its vertex angle. The determined angle should approximate 0^{o} if the area is not folded on the regional scale. If it is cylindrically folded by a single simple phase it should be 180^{o} while if the two phases have affected the outcropping rocks the angle will be moderate.

The field data are expressed in terms of direction cosines and arranged in such determinants.

$$D=\begin{vmatrix} \Sigma p^2 & \Sigma pq & \Sigma p \\ \Sigma pq & \Sigma q^2 & \Sigma q \\ \Sigma p & \Sigma q & \Sigma N \end{vmatrix} \qquad D_i=\begin{vmatrix} -\Sigma pr & \Sigma pq & \Sigma p \\ -\Sigma qr & \Sigma q^2 & \Sigma q \\ -\Sigma r & \Sigma q & N \end{vmatrix} \quad \text{--------- "1"}$$

$$D_j=\begin{vmatrix} \Sigma p^2 & -\Sigma pr & \Sigma p \\ \Sigma pq & -\Sigma qr & \Sigma q \\ \Sigma p & -\Sigma r & N \end{vmatrix} \qquad D_v=\begin{vmatrix} \Sigma p & \Sigma pq & -\Sigma pr \\ \Sigma pq & \Sigma q^2 & -\Sigma qr \\ \Sigma p & \Sigma q & -\Sigma r \end{vmatrix}$$

Three parameters are then determined by the following equation:

$$I=\frac{D_i}{D}, \quad J=\frac{D_j}{D} \quad \& \quad V=\frac{D_v}{D} \qquad \text{------------------------ "2"}$$

The angles $\overline{\gamma}$, $\overline{\alpha}$ and $\overline{\beta}$, ------------→

which the cone axis make with the cartesian coordinates are then determined by the following equations:

$$\cos \bar{\gamma} = (1+I^2+J^2)^{-\frac{1}{2}} \quad \text{"3"}$$

$$\cos \bar{\alpha} = I(1+I^2+J^2)^{-\frac{1}{2}} \quad \text{"4"}$$

$$\cos \bar{\beta} = J(1+I^2+J\ )^{-\frac{1}{2}} \quad \text{"5"}$$

The vertex angle is determined by the following equation:

$$\cos \kappa = -V\ (1+I+J)^{-\frac{1}{2}} \quad \text{"6"}$$

Where κ is half the apical angle of the cone.

The values of: Σp, Σq, Σr, Σp^2, Σq^2, Σpq, Σpr and Σqr; are calculated to be 0.7993, 1.7088, 26.8609, 4.1247, 6.1435, -4.2493, 1.7283, and -1.0076, respectively.

From equation 1, D, D_i, D_j and D_v are determined .

$$D = \begin{vmatrix} 4.1247 & -42493 & 0.7993 \\ -4.2493 & 6\ 1435 & 1.7088 \\ 0.7993 & 1.7088 & 34 \end{vmatrix} = 220.0636$$

$$D_i = \begin{vmatrix} -1.7283 & -4.2493 & 0.7993 \\ 1.0076 & 6.1435 & 1.7088 \\ -26\ 8609 & 1.7088 & 34 \end{vmatrix} = 117.9343$$

$$D_j = \begin{vmatrix} 4.1247 & -1.7283 & 0.7993 \\ -4.2493 & 1.0076 & 1.7088 \\ 0.7993 & -26.8609 & 34 \end{vmatrix} = 169.1585$$

$$D_V = \begin{vmatrix} 4.1247 & -4.2493 & -1.7283 \\ -4.2493 & 6.1435 & 1.0076 \\ 0.7993 & 1.7088 & -26.8609 \end{vmatrix} = -185.1304$$

From equation 2, the three following parameters are determined:

$$I = \frac{117.9343}{220.0636} = 0.5359$$

$$J = \frac{169.1585}{220.0636} = 0.7687$$

$$V = -\frac{185.1305}{220.0636} = -0.8413$$

From equation 3 to equation 6, $\cos\bar{\gamma}$, $\cos\bar{\alpha}$, $\cos\bar{\beta}$ and $\cos\kappa$ are determined:

$$\cos\bar{\gamma} = (1+0.5359^2 + 0.7687^2)^{-\frac{1}{2}} = 0.7297$$

$$\cos\bar{\alpha} = 0.7297 \times 0.5359 = 0.3910$$

$$\cos\bar{\beta} = 0.7297 \times 0.687 = 0.5609$$

$$\cos\kappa = 0.7297 \times 0.841 = 0.6139$$

The above results show that the bedding and contacts are affected by the two fold phases on a major scale.

Structural Analysis of Localities of Iron Deposition

Iron deposition has been discovered in several localities in Bahariya Oasis-El Faiyum area. The deposition of iron in these

localities,as well as in the already known occurrences is structurally controlled.

The localities of iron deposition so far proved in the investigated area are:

1- Northern Bahariya Oasis locality
2- Central Bahariya Oasis locality
3- Southern Bahariya Oasis locality
4- Qaret Had El Bahr locality
5- Gebel Qalamun locality

Structural analysis is carried out in each of these localities to elucidate the major structures. Attention is given to those structures which control the iron deposition or influence the mineralized localities.

1- Northern Bahariya Oasis Locality

Three main iron ore occurrences are outcropping in this locality namely those of Gebel Ghorabi, El Harra, and El Gedida.

The iron ore deposits at Gebel Ghorabi are located on a nearly horizontal fold with a vertical or steeply inclined axial

plane; its inclination is either SE or NW. The average plunge of the axis is 4^{o} $N25^{o}E$ and the mean strike of the axial plane is $N22^{o}E$ which is dipping 78^{o} SE (Plate XI and Table 1).

Another probable anticline is found east of Gebel Ghorabi anticline, both are nearly parallel to each other. The former incorporates the two iron ore deposits of El Gedida and El Harra (Plate X).

These two folds are affected by another younger folding phase which is represented by Gebel Ghorabi second fold (Plate X). The latter's axial trace makes an obtuse angle with the axial traces of the folds belonging to the first generation. The younger fold should therefore affect the iron ore bodies which are controlled geometrically by the shape and attitudes of the first folds. Gebel Ghorabi second fold is also upright of nearly horizontal plunge, its mean axis is plunging on the average 4^{o} $N58^{o}W$ (Plate XII and Table 1).

2- Central Bahariya Oasis Locality

This locality incorporates El Heiz known occurrence and other adjacent occurrences encountered during the present field work.

The iron deposition here is believed to be located on the axes of first folds which have been deformed by the later second fold generation. The Central Bahariya Oasis locality represents, structurally, the top of the culmination resulting from the effect of the second folds on the first, while the northern and the southern localities represent the two reversely plunging tails of the culmination.

In two lithostratigraphic sections (XXX and XLI) measured northwest of Ain El Gharbia and at Gebel Radwan respectively, it has been found out that the iron content increases upwards as the lower stratigraphic horizons are of lower grade. It is considered, therefore, that higher grade iron ores may have been eroded, since this part of this section represents the structural top of the anticline.

The second fold which affected the Central Bahariya Oasis locality is parallel to what is called here, El Hafhuf second fold (Plate X). The geometry of this fold is shown in Table 1 and Plate XIII.

3- Southern Bahariya Oasis Locality

Iron occurrences encountered at this locality are represented in Sections LXII (Sample 250), XLII (Samples 257 and 258), and

LI (Sample 267). The iron deposition is located on Ain Khoman first fold (Plate X), which is an open upright anticline, its axis is statistically plunging 6^{O} $S36^{O}W$, and its mean axial plane is striking S $35^{O}W$ and dipping $79^{O}SE$ (Plate XIV). This fold and its associated iron occurrence are affected by another younger fold, namely Ain Khoman fold 2. The latter's axis is plunging 30^{O} $S39^{O}E$ on an axial plane striking N $37^{O}W$ with a mean dip of 81^{O} SW.

The locality under consideration has a special interest, if it is assumed that the iron deposition in the subsurface has not been extremely reduced for any stratigraphic or other reason, especially by lateral variation. The Southern Bahariya Oasis locality is structurally - though not stratigraphically - corresponding to the Northern Bahariya Oasis locality. At the northern locality, the three known iron occurrences at Gebel Ghorabi, El Gedida, and El Harra are found on the axes of the first folds which are slightly plunging NE, whereas at the southern locality the iron deposition is found at the corresponding folds slightly plunging SW.

4- Qaret Had El Bahr Locality

An iron occurrence is outcropping at this locality (Section V, Sample 34) on an unconformity surface between the lower formation of the Middle Eocene and the overlying Early Miocene rocks. The iron deposition in this locality is thought to be located on the extension of the fold axes controlling El Gedida or Gebel Ghorabi anticlines.

5- Gebel Qalamun Locality

This locality extends from Gebel Qalamun southeastwards to the boundary of the cultivated land of Maghagha, then southwestwards to Qaret Abu Roh due west of El Bahnasa and Samalut. The iron deposition at this locality is outcropping along a curve of some 70 km length (Plate X).

The bedding planes and contacts in the discussed locality are approximately horizontal. When they are projected, their poles are distributed in a partial great circle expressing a weak regional folding. Two fracture systems are encountered, each of them has a strike concomitant with the two main directions of the axial trace of this major fold.

The mean vector of the bedding planes and contacts, and accordingly their plane of best fit, are determined. The value of this plane will be used in the structural computations or the detailed exploration at this locality since it represents the statistical mean value. The mean vector is the normal to the plane of best fit, which in projection (Plate XIX) is the locus of limb maxima of the two sides of the curved fold. The two planes containing the mean value of fractures represent two girdles of the two sides of the fold. It is obvious in Plate XIX that the fold axis is either horizontal and trending NE (in the southern part of the locality) or plunging 2^{o}NW (in its northern part).

Table 1 : Geometrical Elements of Major Folds at El Bahariya Oasis - El Farafra Oasis Depressions

	Fold	Axis		Axial plane		Accompanied Fractures			Unaccompanied fractures	
		Trend	Plunge	Strike	Mean dip	Strike	Dip	Kind	Strike	Dip
First Folds	Gebel Ghorabi anticline	N25°E	4°	N22°E	78°SE	WNW-ESE NNE-SSW	NNE & SSW ESE & WSW	AC AB	NNW	WSW
	Ain Khoman anticline	S36°W	6°	S35°W	79°SE	NE-SW	NW	AB	ENE	SSE
	Naqb El Sellim	N13°W	11°	N13°W	79°E	NNW-SSE ENE-WSW	WSW SSE	AB AC		
	Farafra Oasis	S42°W	8°	N47°E	72°SE	NE-SW	SE	AB	ENE	NNW & SSE
Second Folds	Gebel Ghorabi	N58°W	4°	N62°W	78°NE	NE SW NW-SE	NW & SE NE & SW	AC AB	NNE	ESE
	El Hafhuf	N72°W	10°	E - W	30°N	NNE-SSW	WNW	AC	NE	SE
	Ain Khoman	S39°E	3°	N37°W	81°SW	NE-SW	SE	AC	NNW	WSW
	Farafra Oasis	N54°W	0°	N54°W	78°SW	NW-SE	NE & SW	AB	NNW ENE	ENE NNW

CHAPTER II

GEOLOGICAL CRITERIA OF IRON DEPOSITION

Deposition of iron started in the Late Cretaceous and continued in the Middle Eocene especially its lower formation. It has been proved during the present work that the iron occurrence at El Heiz in the central part of Bahariya Oasis is actually belonging to the Late Cretaceous and not to the Oligocene. It is considered here that the Oligocene and Miocene may be periods of ferrugination particularly enhanced by volcanic activity but not periods of iron deposition leading to the formation of ore deposits. Accordingly iron ore deposits of economic potential in the Bahariya Oasis-El Faiyum area are believed to be restricted only to the Cretaceous-Eocene geological units. Hence exploration activities should be directed towards these units especially in the top parts of the Cretaceous and the bottom parts of the Middle Eocene within the sphere of influence of the previously mentioned structures.

The main geological conditions of the known and newly discovered iron occurrences in the regionally investigated area are as follows:

1- <u>Northern Bahariya Oasis Locality</u>

The iron ore deposits of El Gedida, Gebel Ghorabi and El Harra are occurring in this locality. The iron ores are normally encountered in the lower formation of the Middle Eocene (El Shazly, 1962a; El Akkad and Issawi, 1963; Mahgoub and Amer, 1964). In addition it has been stated by Bassyony (1970) that the lower economic iron ore beds in El Harra represent a member of the Late Cretaceous "El Hafhuf Formation".

The aim of the present work in this locality is to connect regionally the known iron ore deposits from the geological and structural point of view. These deposits have been found to be actually dominated by Laramide folding acting on the Late Cretaceous-Middle Eocene geological units. The same structural conditions have been noted in the northern extension of this locality towards the north of the already known deposits.

Apart from the well established iron ore deposits in the Middle Eocene rocks,iron occurrences have been encountered during the present work in the Late Cretaceous rock units in the Northern Bahariya Oasis locality which are illustrated in Table 2. Both samples analyzed from these occurrences are high in salts especially sample No. 208.

Table 2. Analysis of Samples from Late Cretaceous Rocks in Northern Bahariya Oasis Locality *

Sample No.	200	208
Location	5 Km NNW El Harra	Gebel Ghorabi
Thickness	0.1	15
SiO_2 wt%	3.02	9.92
Al_2O_3 wt%	4.07	1.02
Fe_2O_3 "	70.25	63.58
FeO "	Tr.	Tr.
CaO "	1.68	0.67
MgO "	2.06	2.42
Na_2O "	1.46	7.55
K_2O "	0.63	0.48
H_2O^- "	3.20	0.70
L.O.I. "	9.60	7.80
Cl "	1.56	7.88
SO_3 "	1.76	1.30
P_2O_5 "	1.31	0.09
TiO_2 "	0.04	Tr.

* Chemical analyses by Dr. M.M. Ali.

2- Central Bahariya Oasis Locality

The iron occurrence of El Heiz outcropping in this locality is stated by Ball and Beadnell (1903) to be of Oligocene age based on the lithologic similarity with the Oligocene rocks in northern Egypt. Later authors followed the same age assignment given by Ball and Beadnell, however, in the present work the iron occurrence under discussion is assigned to the Late Cretaceous. El Shazly (1962b) considers the dark brown low grade iron ore encountered at El Heiz as constituted of goethite replacing quartz grains along their boundaries, associated with small amounts of manganese oxide, lime and clay.

Two new sections have been measured in the Central Bahariya Oasis locality showing the presence of iron, namely XXX and XXXI at NW Ain El Gharbia (Plate XXVI) and Qaret El Sheikh (Plate XXVII) respectively. (For description of the lithostratigraphic sections, reference is made to the mentioned plates. However, the analyzed iron samples are collected from two horizons of Late Cretaceous sandstones in the case of the section to the NW of Ain El Gharbia and from a Late Cretaceous clayey horizon in the case of the section at Qaret El Sheikh.)

Chemical analyses of the samples collected from the Central Bahariya Oasis locality are given in Table 3. It may be noted that there is a high silica trend in the analyzed samples except sample 181 which is very high in iron. The chloride content is low in sample No. 188 and 183, high in sample No. 181 and very conspicuous in sample No. 185.

Table 3. Analysis of Samples from Late Cretaceous Rocks in Central Bahariya Oasis Locality

Sample No.	181	183	185	188
Location	E Ain El Gharbia	NW Ain El Gharbia		Qaret El Sheikh
Section No.		XXX	XXX	XXXI
Horizon No.		2	4	2
Thickness	Unknown	Patchy	Not regular	Unknown
SiO_2 wt%	3.55	53.50	16.05	56.3
Al_2O_3 "	2.04	2.55	1.79	0.89
Fe_2O_3 "	80.43	34.97	63.23	30.18
FeO "	Tr.	Tr.	Tr.	Tr.
CaO "	0.67	0.67	1.01	1.01
MgO "	1.93	1.93	2.42	1.93
Na_2O "	1.29	0.43	6.04	0.32
K_2O "	0.24	0.63	0.48	0.19
H_2O^- "	1.64	0.56	0.40	0.10
L.O.I. "	5.76	3.00	2.80	7.20
Cl "	1.21	0.50	7.24	0.14
SO_3 "	0.70	0.68	0.52	0.81
P_2O_5 "	0.37	0.18	0.85	0.42
TiO_2 "	0.03	0.21	0.04	0.05

3- Southern Bahariya Oasis Locality

Iron occurrences have been found in this locality in the exposed Late Cretaceous rocks. The structural features of this locality as explained earlier is comparable to those of the Northern Bahariya Oasis locality. Three lithostratigraphic sections showing the presence of iron have been measured in the discussed locality; these are XLII at Ain Khoman and XLIII at Nagb El Sellim. These sections are illustrated and described in Plates XXVIII and XXIX respectively. The iron in these sections is associated with Late Cretaceous clay and sandstone.

Chemical analyses of samples collected from sections XLII and XLIII are given in Table 4. These samples show high silica content, while the salts are high in sample No. 250 and especially so in sample No. 257 and sample No. 258.

Table 4. Analysis of Samples from Late Cretaceous Rocks in Southern Bahariya Oasis Locality

Sample No.	250	257	258
Location	Ain Khoman	Naqb El	Sellim
Section No.	XLII	XLIII	XLIII
Horizon No.	1	1	2
Thickness	2 m	0.3 m	Patchy
SiO_2 wt %	9.50	13.42	25.85
Al_2O_3 "	3.83	4.59	4.59
Fe_2O_3 "	58.83	43.51	28.74
FeO "	Tr.	Tr.	Tr.
CaO "	1.68	4.37	2.35
MgO "	4.80	5.56	5.56
Na_2O "	1.62	4.04	9.71
K_2O "	0.63	1.21	1.16
H_2O^- "	4.84	3.80	3.70
L.O.I. "	11.60	9.80	8.10
Cl "	3.20	5.11	11.67
SO_3 "	0.20	5.44	2.86
P_2O_5 "	0.20	0.92	0.83
TiO_2 "	0.05	0.50	0.04

4- Qaret Had El Bahr Locality

This locality is found towards the NE of Bahariya Oasis and it shows the same structural features encountered in the Northern Bahariya Oasis locality. The geological succession at Qaret Had El Bahr is constituted of the lower formation of the Middle Eocene overlain unconformably by the Early Miocene Gebel El Khashab Formation (Section V, Plate XXII). The iron bearing horizon in this section is dark brown sandstone passing into conglomerate towards the top, and it is localized at the unconformity between the Middle Eocene and the Early Miocene.

The chemical analysis of a sample from Qaret Had El Bahr is shown in Table 5. The sample is characterized by a high silica content though it is low in salts.

Table 5. Analysis of a Sample from Middle Eocene-Early Miocene Unconformity Qaret Had El Bahr Locality

Sample No.	34
Location	Qaret Had El Bahr
Section No.	V
Horizon No.	4
Thickness (m)	4.8 Horizon
SiO_2 wt %	63.40
Al_2O_3 "	1.02
Fe_2O_3 "	23.94
FeO "	1.63
CaO "	2.69
MgO "	0.96
Na_2O "	0.14
K_2O "	0.18
H_2O^- "	0.30
L.O.I. "	4.80
Cl "	0.14
SO_3 "	0.32
P_2O_5 "	0.21
TiO_2 "	0.08

5- Gebel Qalamun Locality

Iron deposition has been found to be widely spread in Gebel Qalamun Locality in the eastern part of the investigated Bahariya Oasis-El Faiyum area. The structural conditions have been proved to be comparable to those of Bahariya Oasis and the geological unit enclosing the iron deposition is equivalent to the lower formation of the Middle Eocene where the iron ore deposits of El Gedida, Gebel Ghorabi and El Harra are present.

Four lithostratigraphic sections have been measured in the discussed locality namely No. II, VIII, XIV and XV (Plates XXI, XXIII, XXIV and XXV). The iron-bearing samples are encountered in the shaly horizons of the lower Middle Eocene formation. The samples tend to be high in silica or carbonates or both, and they may contain a wide range of chloride and sulphite from low to high.

Table 6. Analysis of Samples from Middle Eocene Rocks at Gebel Qalamun Locality

Sample No.	25	48	53	93	95
Location	DeirSamuel	Gebel Qalamun	2 Km NW Deir Samuel	6 Km SE Deir Samuel	5 Km SE Deir Samuel
Section No.	II	VIII		XIV	
Horizon No.	4	1		2	
Thickness(m)	0.6-1.2 each bed	7 Shale bed	Unknown	Patchy	Unknown
SiO_2 wt %	4.80	23.40	23.40	13.20	8.50
Al_2O_3 "	1.79	3.06	3.06	3.57	1.79
Fe_2O_3 "	24.74	39.57	26.83	49.82	59.00
FeO "	0.04	0.04	0.08	0.04	0.04
CaO "	19.49	11.09	5.04	6.38	7.06
MgO "	14.75	2.18	5.08	1.93	3.14
Na_2O "	2.29	2.83	8.76	2.76	2.02
K_2O "	0.24	0.42	1.69	0.22	0.30
H_2O^- "	0.84	2.16	4.80	3.20	3.20
L.O.I. "	23.96	12.00	10.54	12.00	10.50
Cl "	0.39	0.78	11.74	2.50	0.56
SO_3 "	6.54	1.75	2.92	2.33	3.63
P_2O_5 "	0.23	0.31	0.36	1.86	0.58
TiO_2 "	0.08	0.25	0.08	0.21	0.08

Table 6. (Cont'd)

Sample No.	97	99	101	133	176
Location	8 Km SE Deir Samuel	SE Deir Samuel	E Deir Samuel	NW El Bahnasa	10 Km W El Bahnasa
Section No.	XV				
Horizon No.	2				
Thickness(m)	0.2	Unknown	0.25	Unknown	Unknown
SiO_2 wt %	7.20	24.80	5.14	13.40	8.00
Al_2O_3 "	3.06	3.06	6.00	3.32	3.83
Fe_2O_3 "	33.09	33.85	29.50	40.17	43.01
FeO "	0.14	0.04	0.04	2.58	Tr.
CaO "	20.16	8.40	19.49	6.72	5.38
MgO "	0.90	1.03	0.24	0.73	8.85
Na_2O "	0.81	2.16	0.54	7.33	9.38
K_2O "	0.18	0.90	0.60	0.12	0.34
H_2O^- "	3.20	5.30	2.00	2.00	4.20
L.O.I. "	21.00	10.20	6.30	8.00	10.24
Cl "	0.39	4.54	3.69	8.93	9.02
SO_3 "	9.15	6.07	27.84	10.09	0.20
P_2O_5 "	0.31	1.38	0.17	0.46	1.23
TiO_2 "	0.21	0.42	0.05	0.20	0.02

RECOMMENDATIONS

As a result of analysis presented in previous discussions and after careful consideration of all factors involved, the localities selected for further prospecting and exploration are shown on the map of Bahariya Oasis-El Faiyum area (Plate X). These localities are arranged into three categories of priorities:

Priority No. 1: Localities selected for immediate prospecting and exploration.

These include Northern Bahariya Oasis locality (1) and Gebel Qalamun locality (2). Two pieces covering 1600 km^2 are chosen in the two localities for second phase prospecting and exploration during 1976. The choice is based on the favorable geological and structural conditions, the presence of iron deposition in exposures or under shallow depths, and the simplicity of the infra structure.

Priority No. 2: Localities selected for medium term prospecting and exploration.

These include Qaret Had El Bahr locality (3) and Ghard Ghorabi locality (4) in the vicinity of Northern Bahariya Oasis locality, and West El Faiyum locality (5) to the west of Gebel Qalamun area. The progress of work in the medium term stage will depend

on the results achieved in localities (1) and (2). The choice of localities of Priority No. 2 is based on favorable structural conditions and the possible link in infrastructure with the development of either Northern Bahariya Oasis locality or Gebel Qalamun locality. The thickness of the overburden and its nature will play an important role in the prospecting and exploration costs to be incurred in the second priority localities.

Priority No. 3: The selected localities for long term prospecting and exploration include Central Bahariya Oasis locality (6) and Southern Bahariya Oasis locality (7), as well as West Giza locality (8).

These areas, although favorable from the structural point of view, yet they require separate infrastructure. Furthermore, in localities (6) and (7) only Late Cretaceous rocks are present while in locality (8) the favorable rocks for iron deposition are expected to be encountered at a depth of about 600 m or more.

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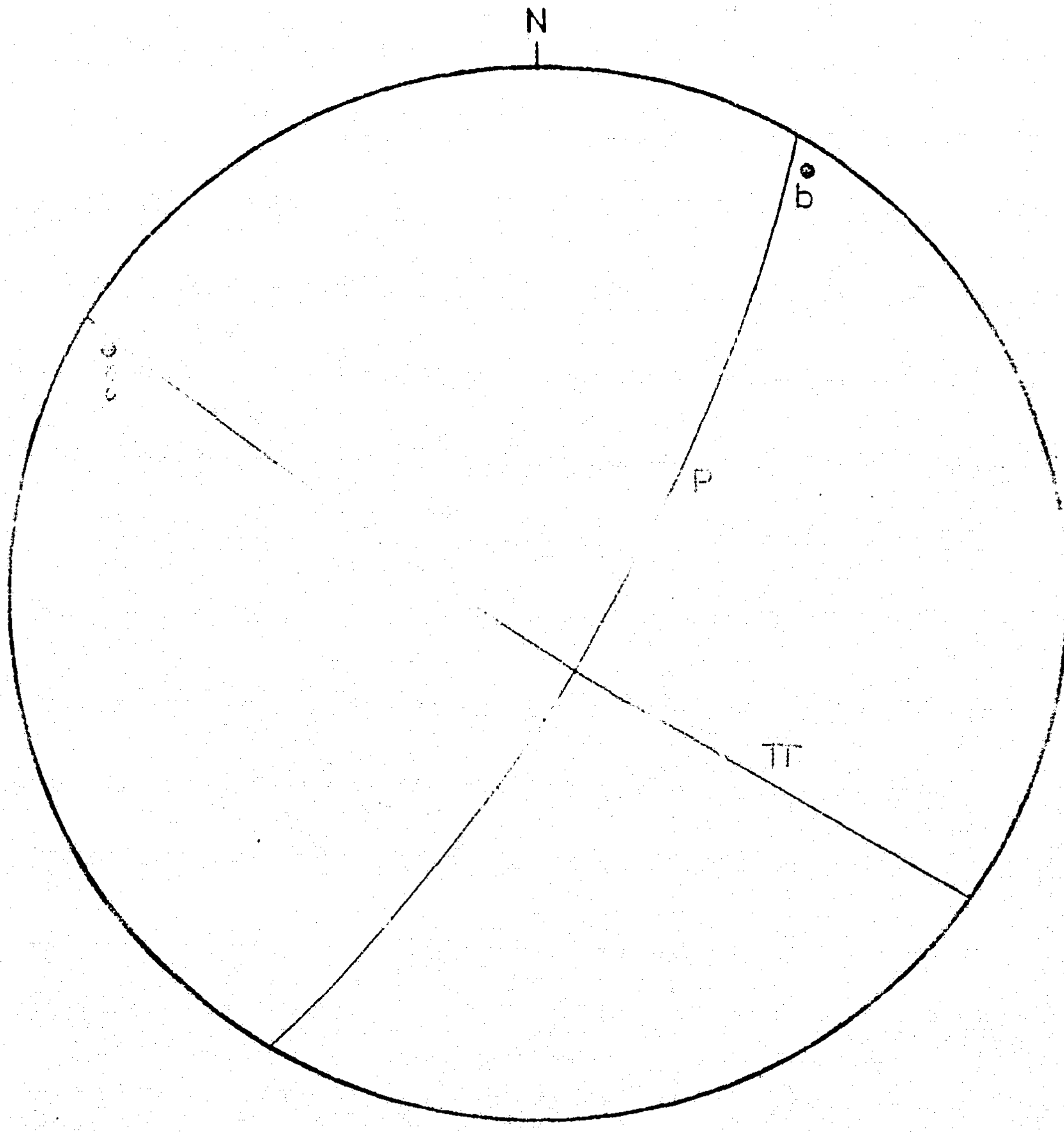
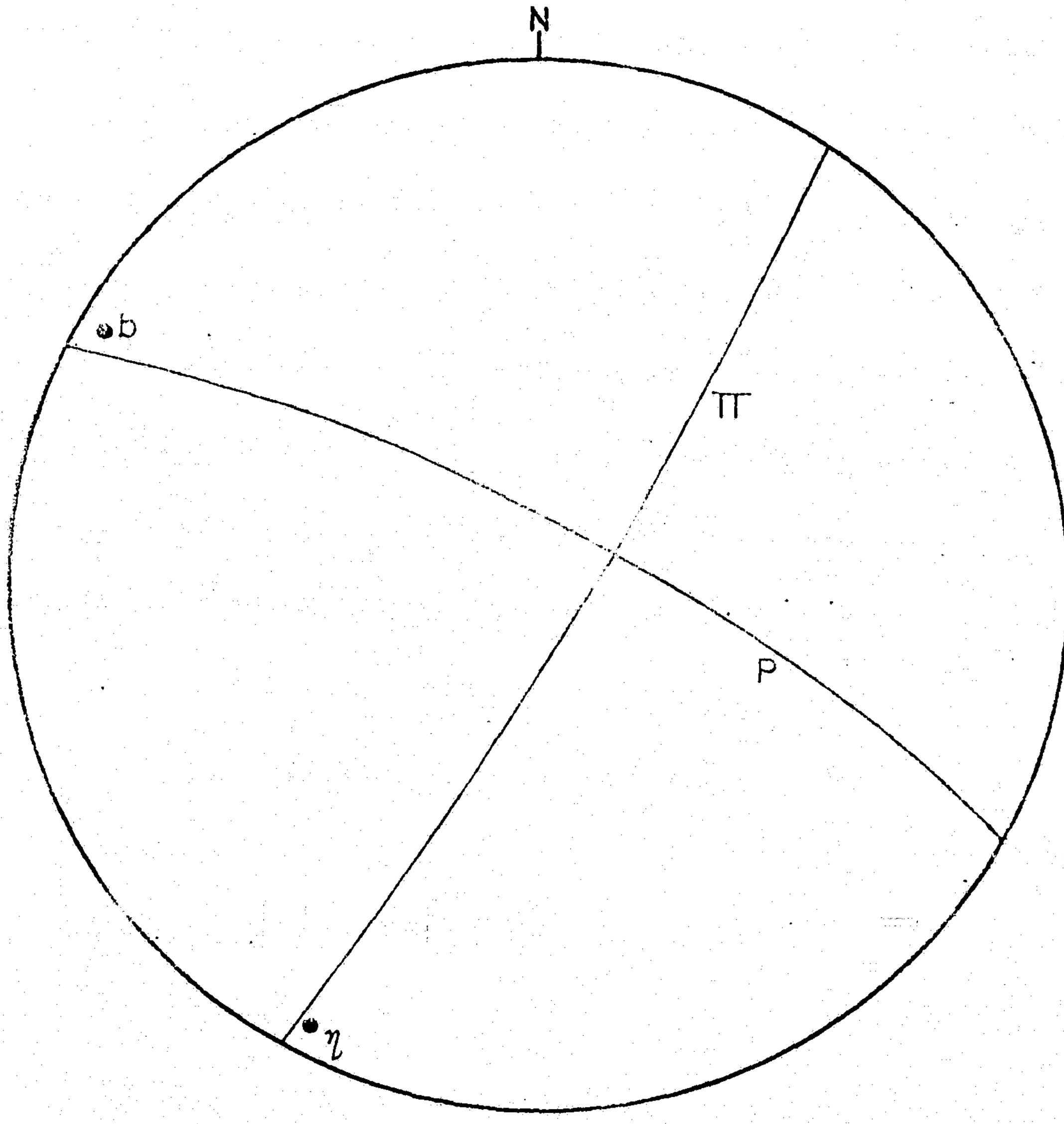


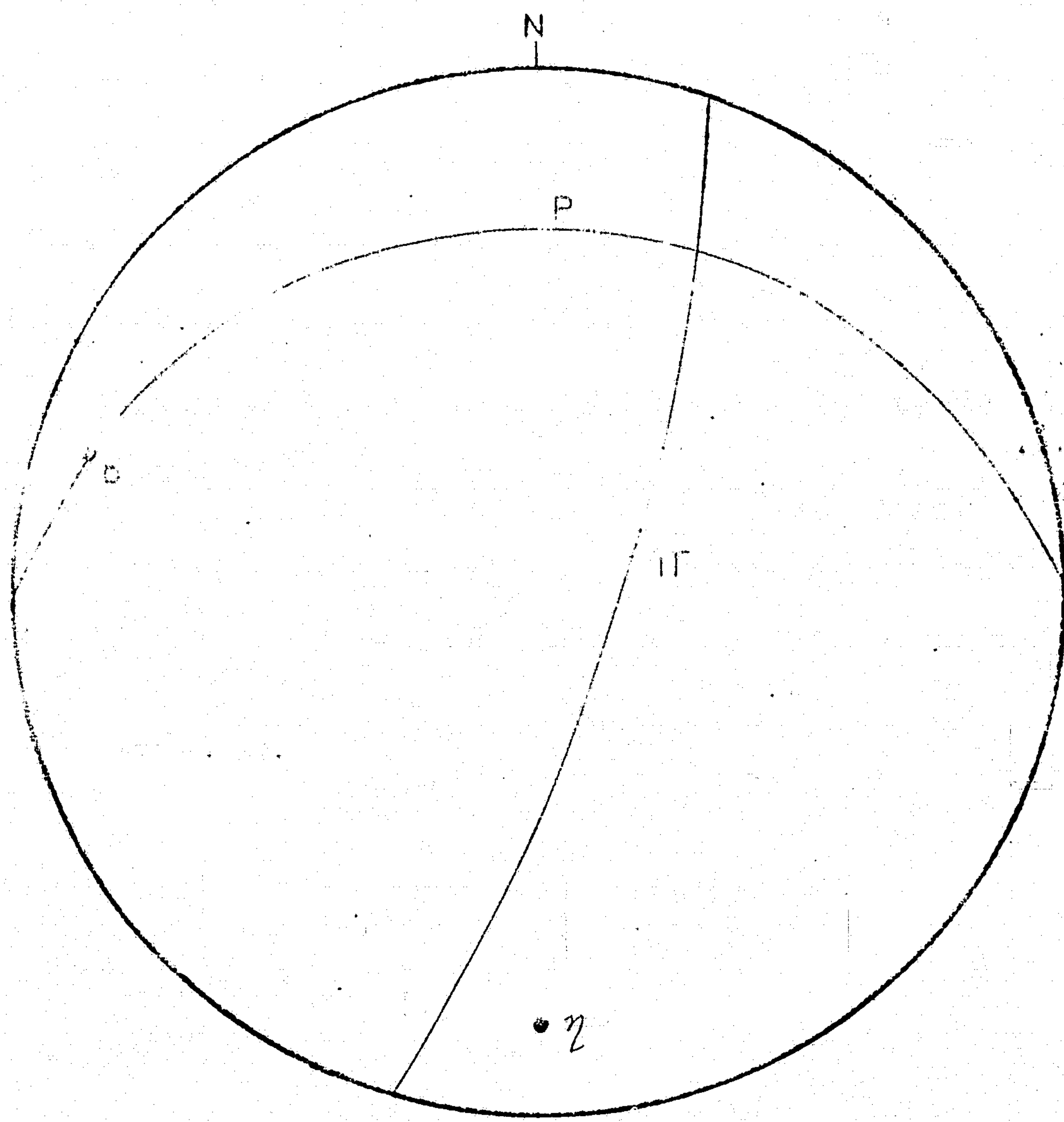
GEOMETRY OF GEBEL GHORABI FIRST FOLD

π GIRDLE OF BEST FIT
P DETERMINED AXIAL PLANE
b ● STATISTICAL FOLD AXIS
Z ● MEAN POLE TO THE AXIAL PLANE



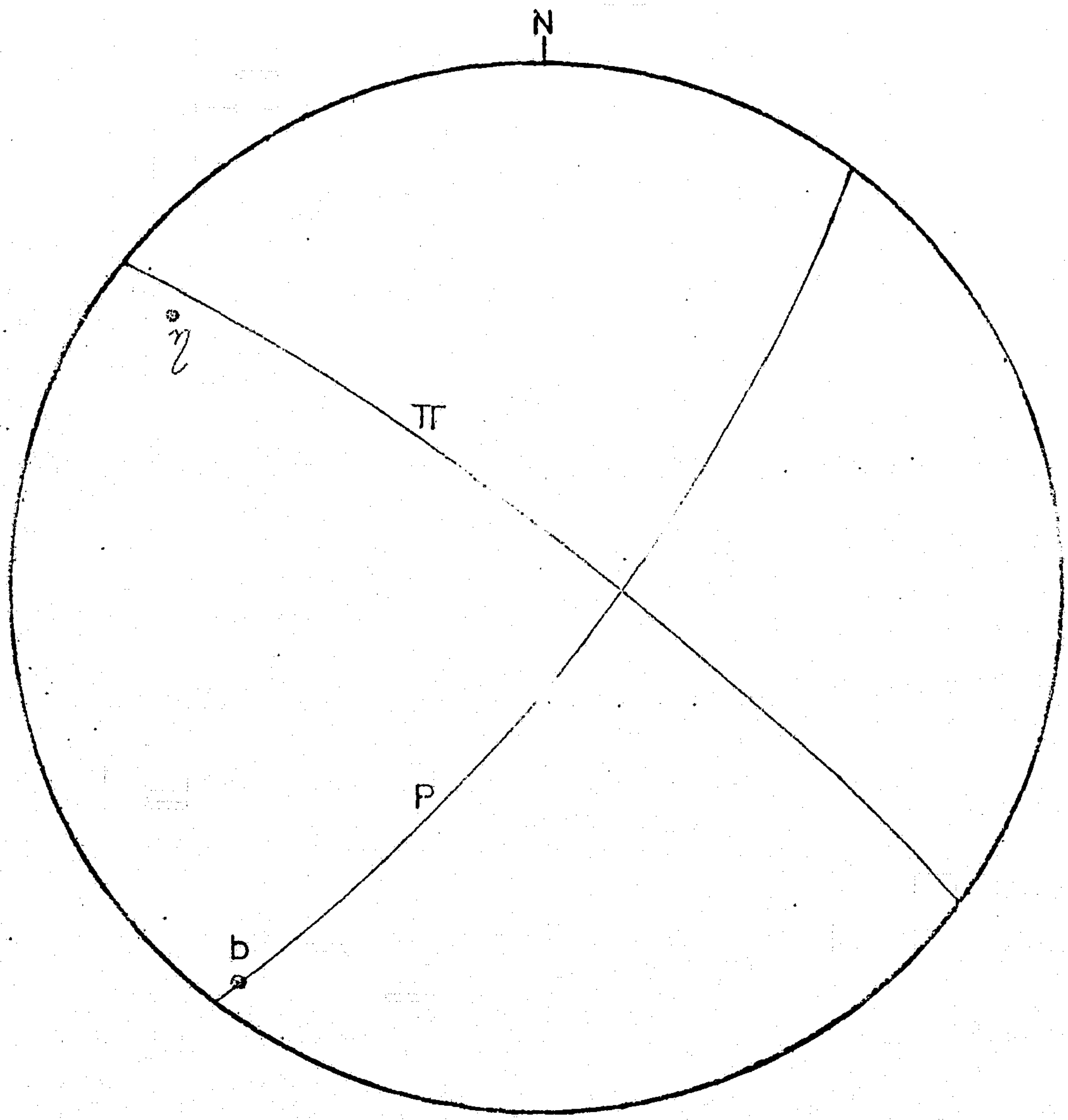
GEOMETRY OF GEBEL GHORABI SECOND FOLD

π GIRDLE OF BEST FIT
P DETERMINED AXIAL PLANE
b • STATISTICAL FOLD AXIS
η • MEAN POLE TO THE AXIAL PLANE



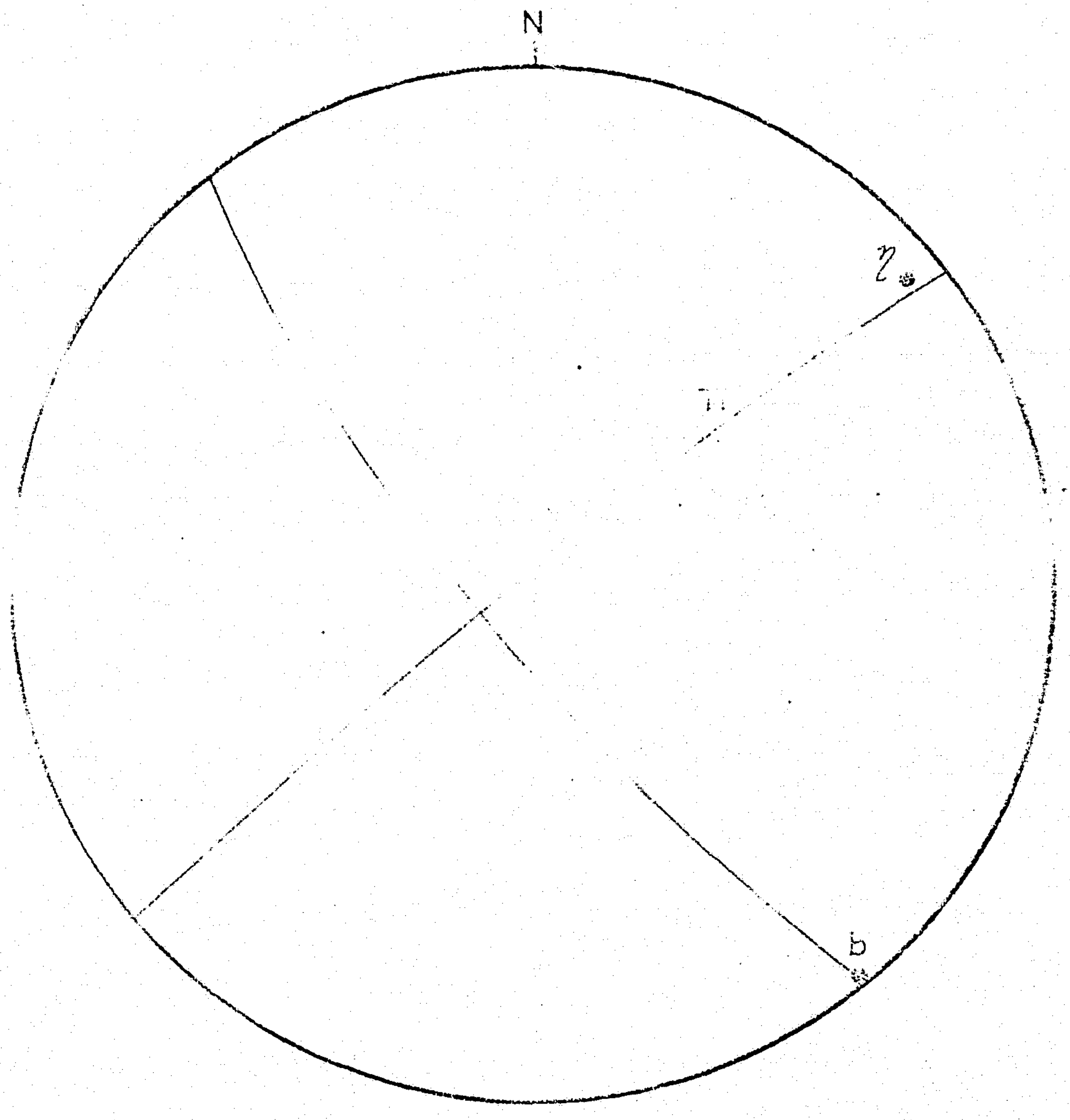
GEOMETRY OF EL HAFHUF SECOND FOLD

π GIRDLE OF BEST FIT
P DETERMINED AXIAL PLANE
b • STATISTICAL FOLD AXIS
η • MEAN POLE TO THE AXIAL PLANE



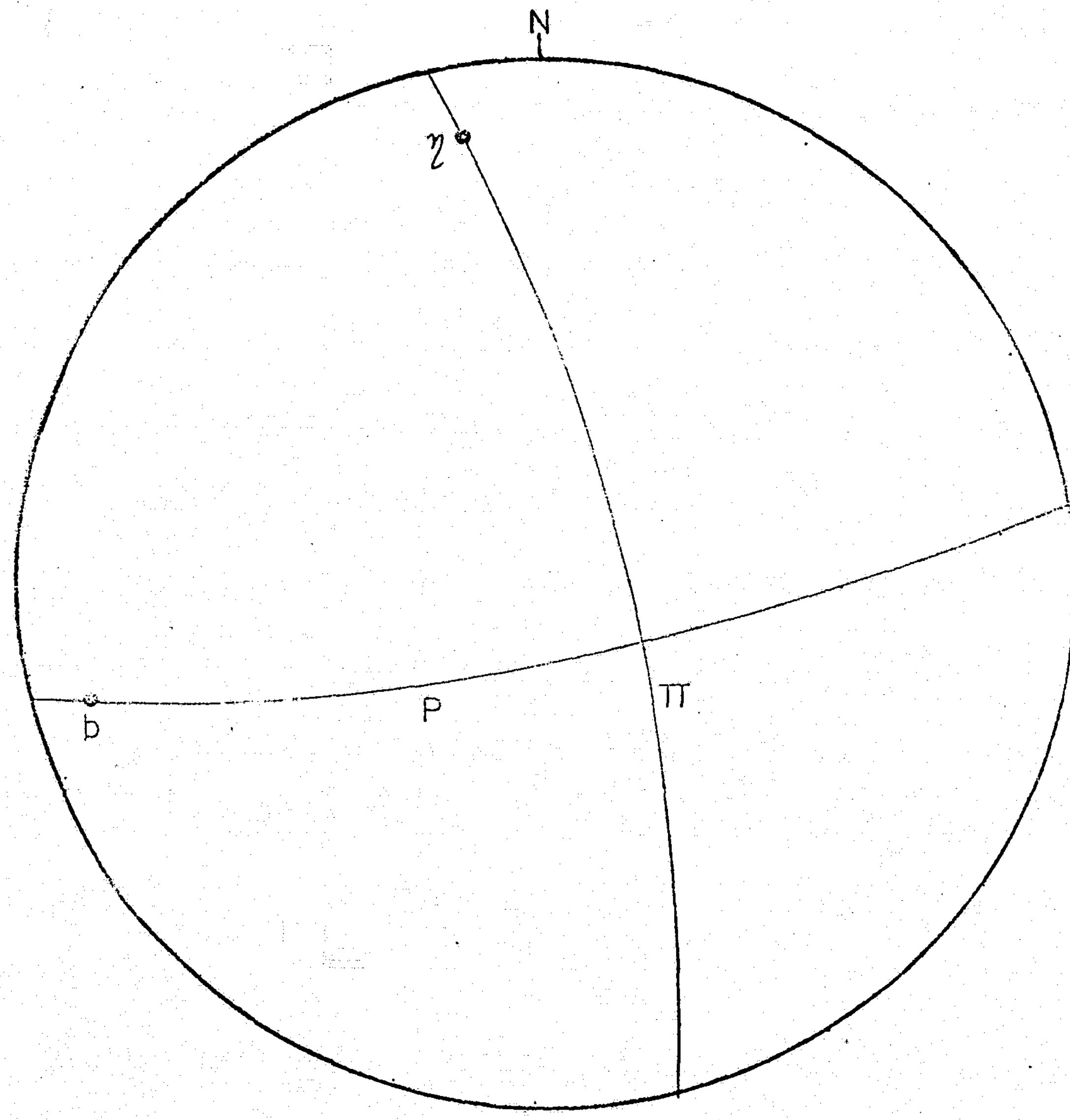
GEOMETRY OF AIN KHOMAN FIRST FOLD

π GIRDLE OF BEST FIT
P DETERMINED AXIAL PLANE
b STATISTICAL FOLD AXIS
η MEAN POLE TO THE AXIAL PLANE



GEOMETRY OF AIN KHOMAN SECOND FOLD

π GIRDLE OF BEST FIT
P DETERMINED AXIAL PLANE
b • STATISTICAL FOLD AXIS
η • MEAN POLE TO THE AXIAL PLANE



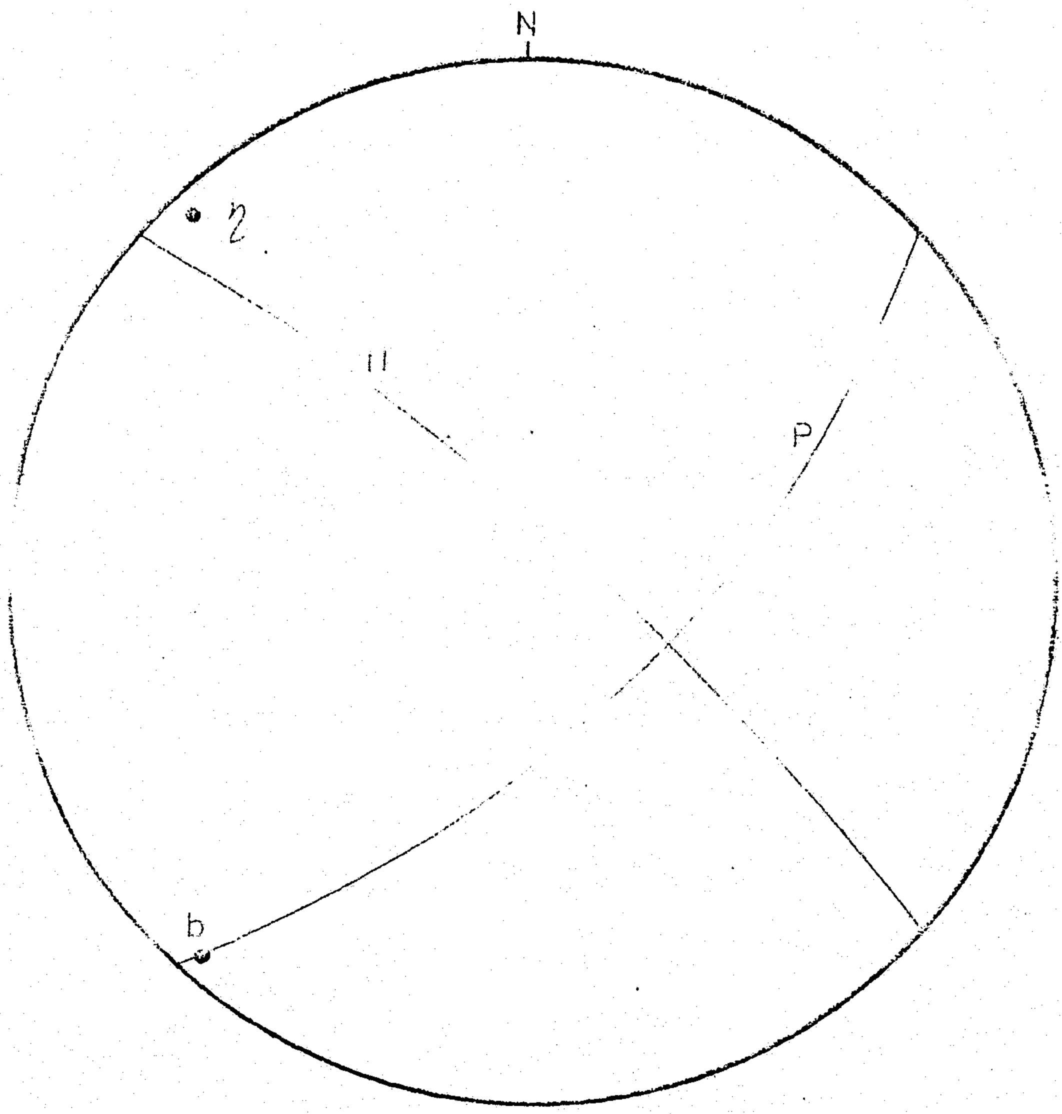
GEOMETRY OF NAQB EL SELLIM FIRST FOLD

π GIRDLE OF BEST FIT

P DETERMINED AXIAL PLANE

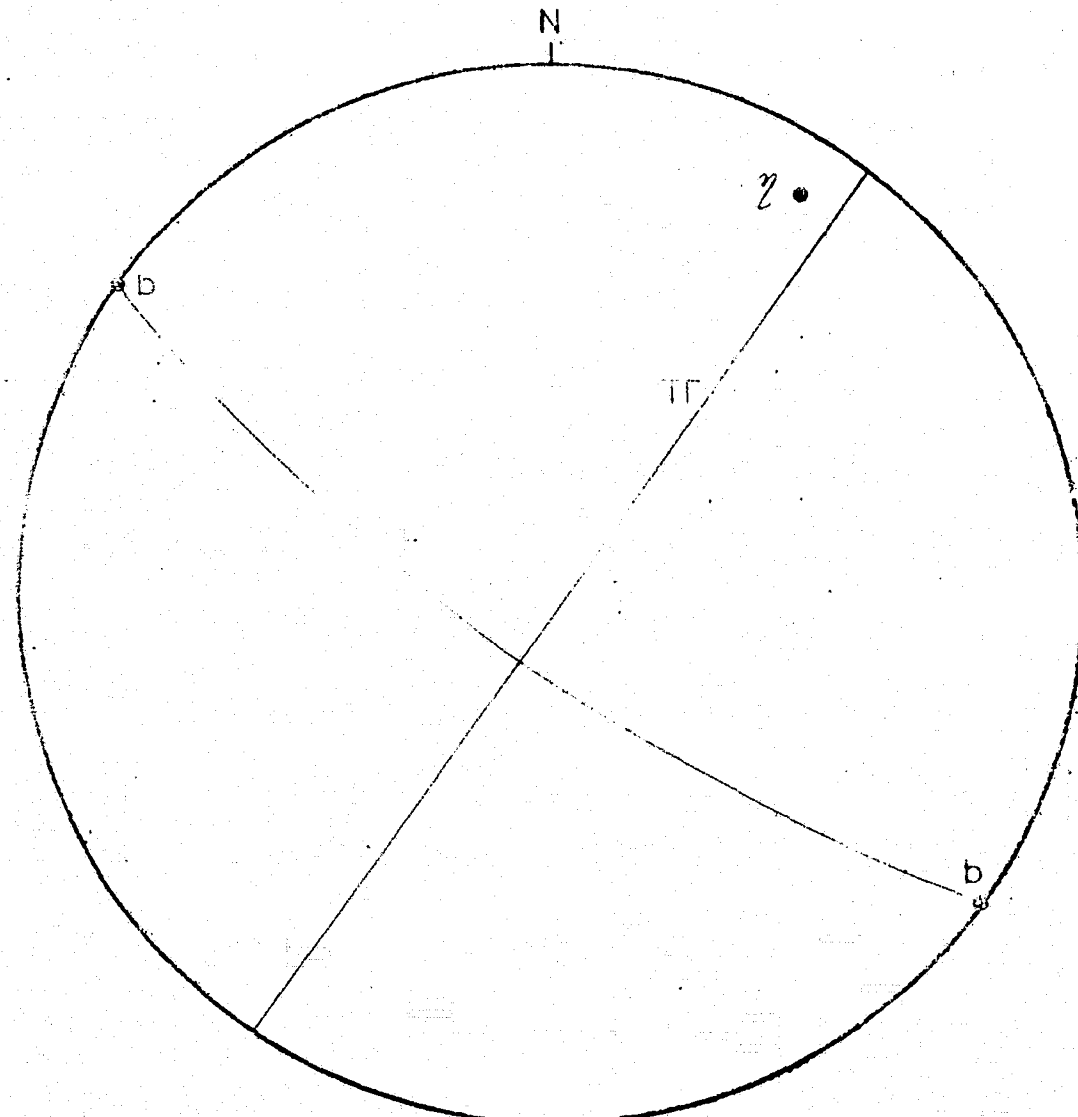
b ● STATISTICAL FOLD AXIS

η ● MEAN POLE TO THE AXIAL PLANE



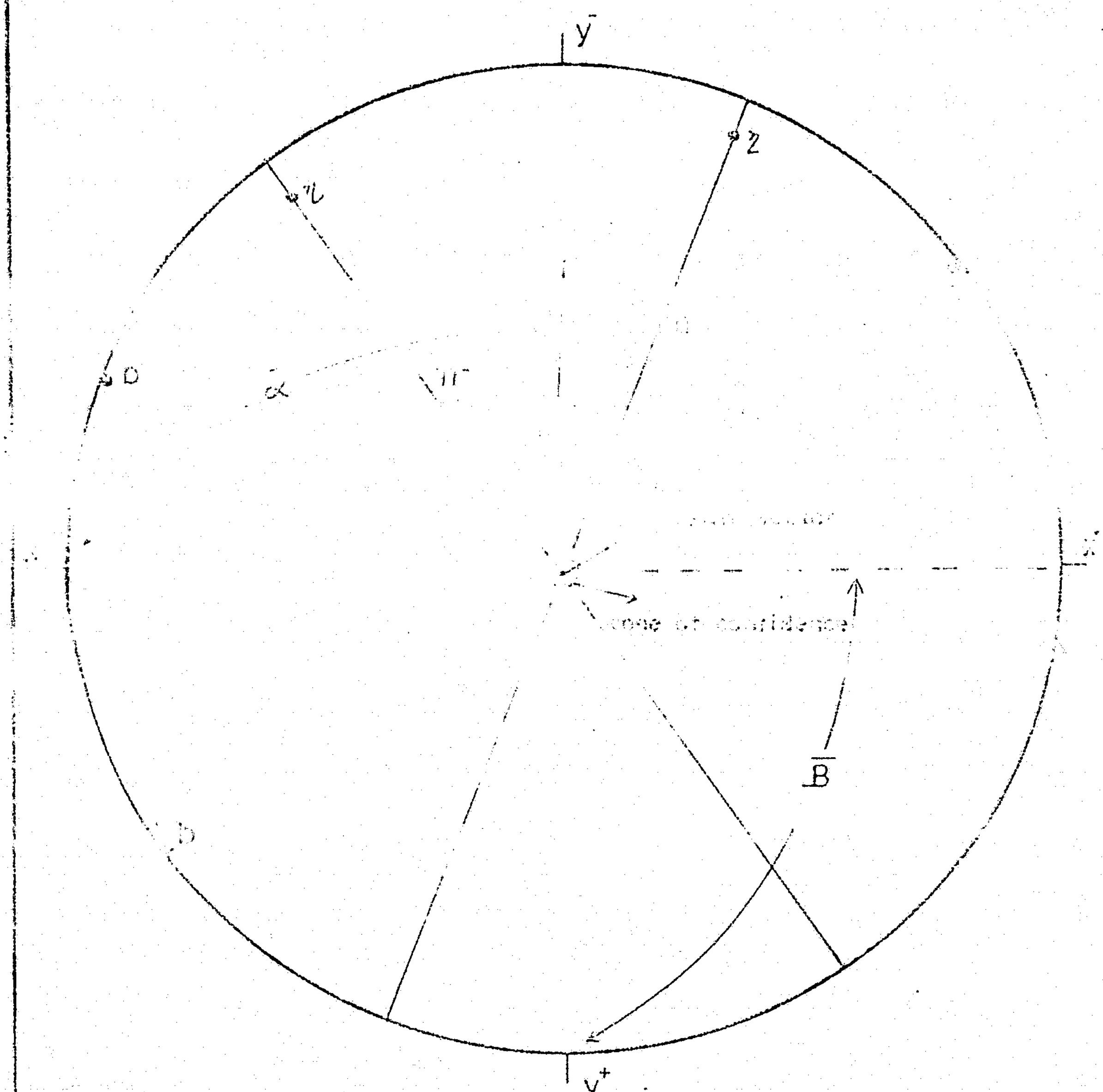
GEOMETRY OF FARAFRA OASIS FIRST FOLD

π GIRDLE OF BEST FIT
P DETERMINED AXIAL PLANE
• STATISTICAL FOLD AXIS
η • MEAN POLE TO THE AXIAL PLANE



GEOMETRY OF FARAFRA OASIS SECOND FOLD

π GIRDLE OF BEST FIT
P DETERMINED AXIAL PLANE
b STATISTICAL FOLD AXIS
η MEAN POLE TO THE AXIAL PLANE

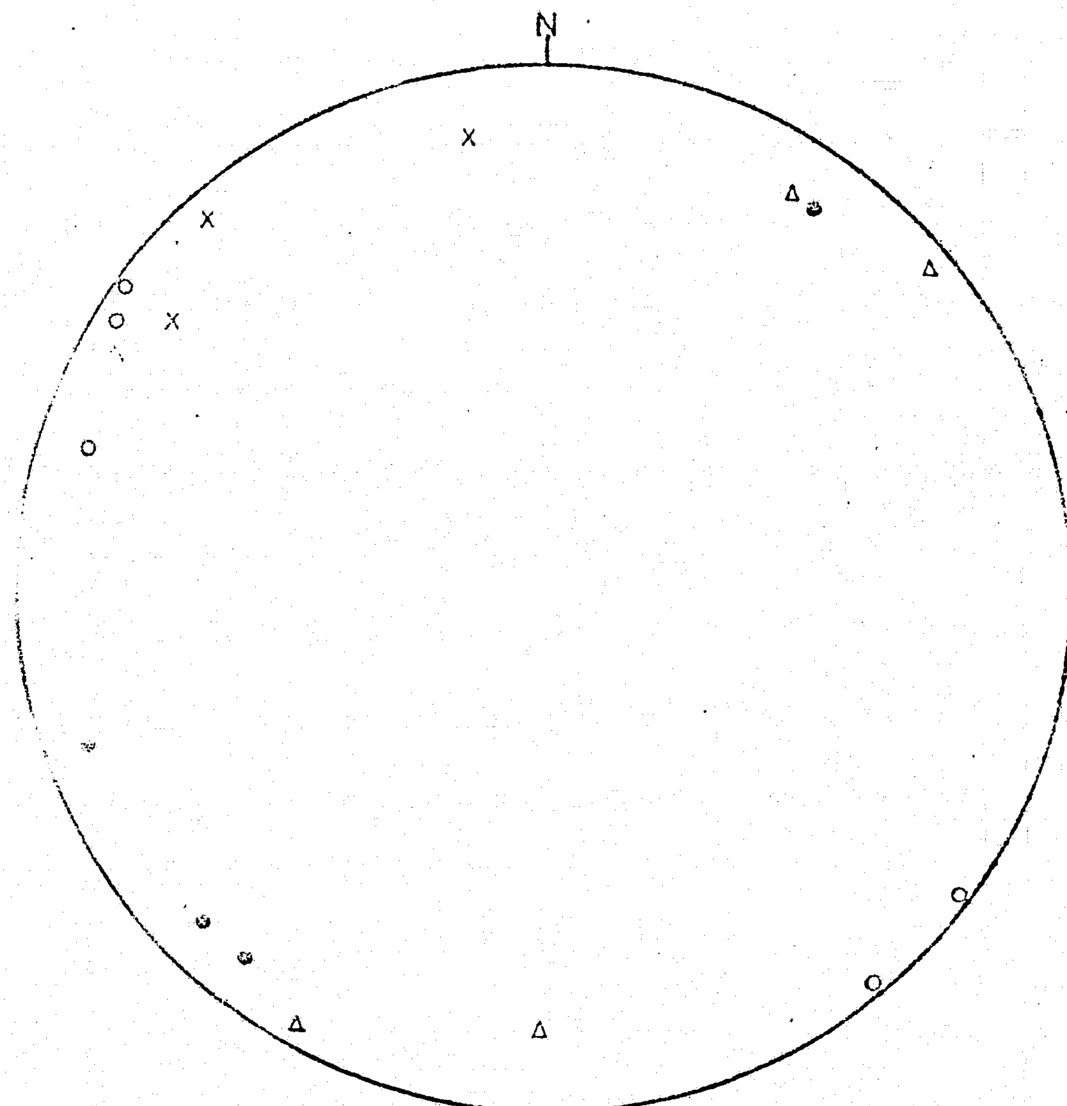


GEOMETRY OF GEBEL QALAMUN FOLD

π GIRDLE OF BEST FIT

b STATISTICAL FOLD AXIS

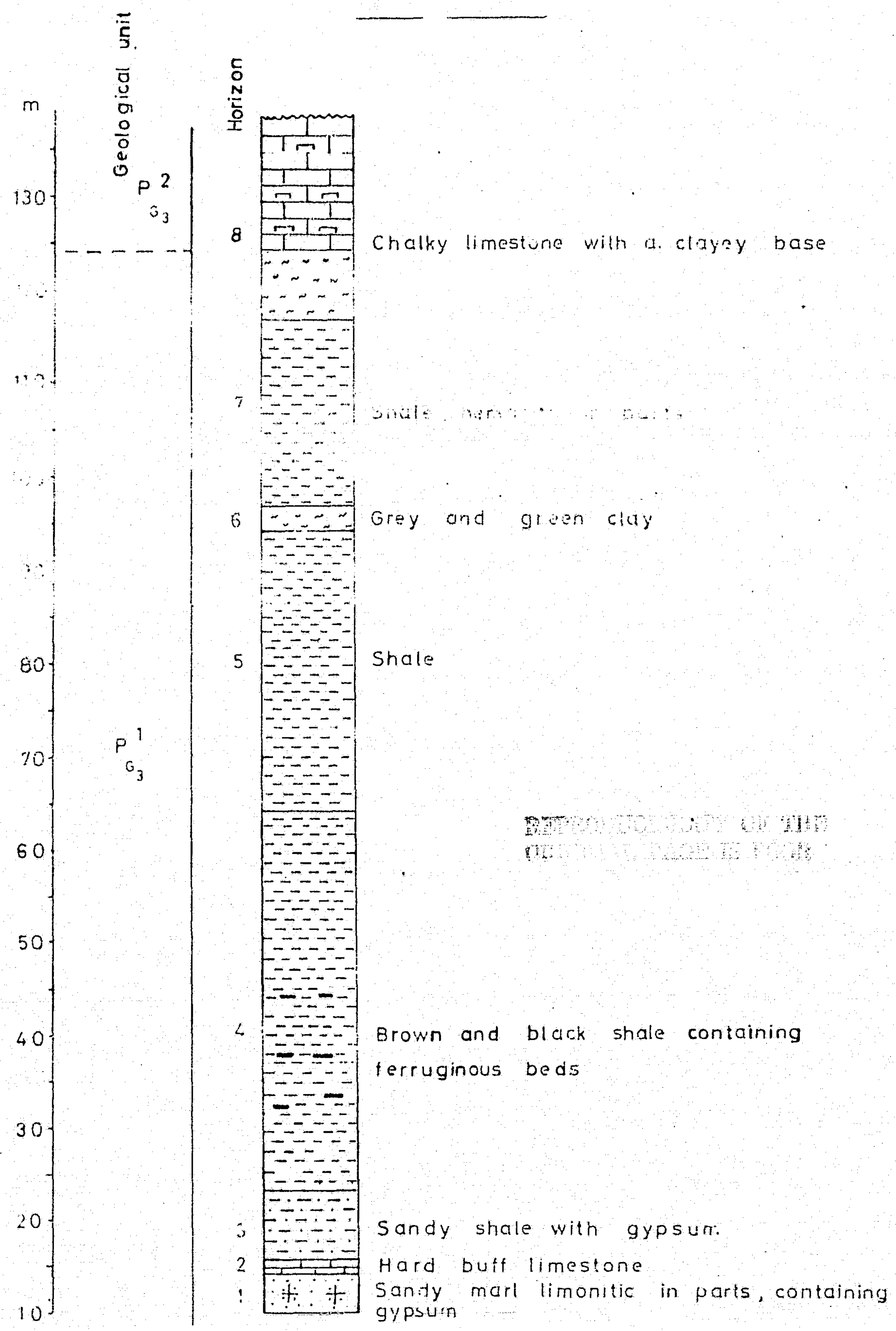
η MEAN POLE TO AB FRACTURE



SYNOPTIC DIAGRAM OF THE MAJOR FOLDS

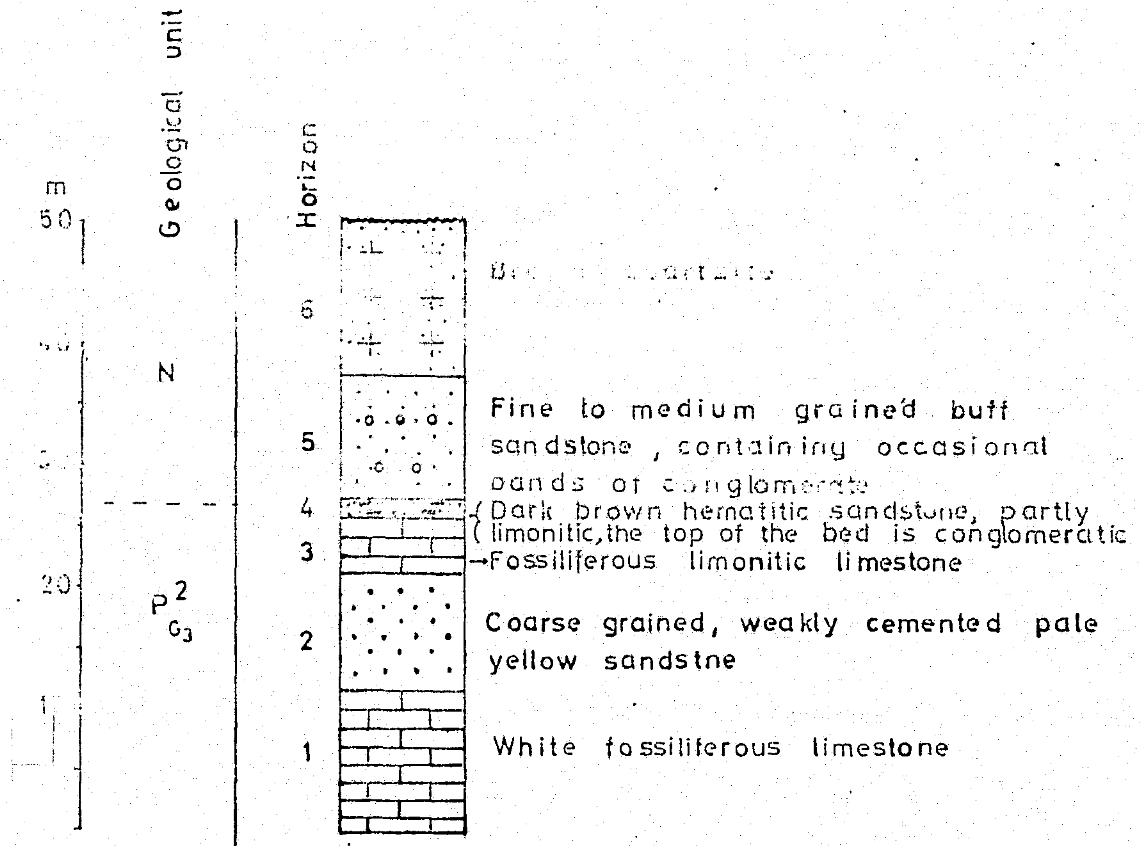
- ● STATISTICAL AXIS OF A FIRST FOLD
- ○ STATISTICAL AXIS OF A SECOND FOLD
- x MEAN AXIAL PLANE OF A FIRST FOLD
- △ MEAN AXIAL PLANE OF A SECOND FOLD

LITHOSTRATIGRAPHIC SECTION II



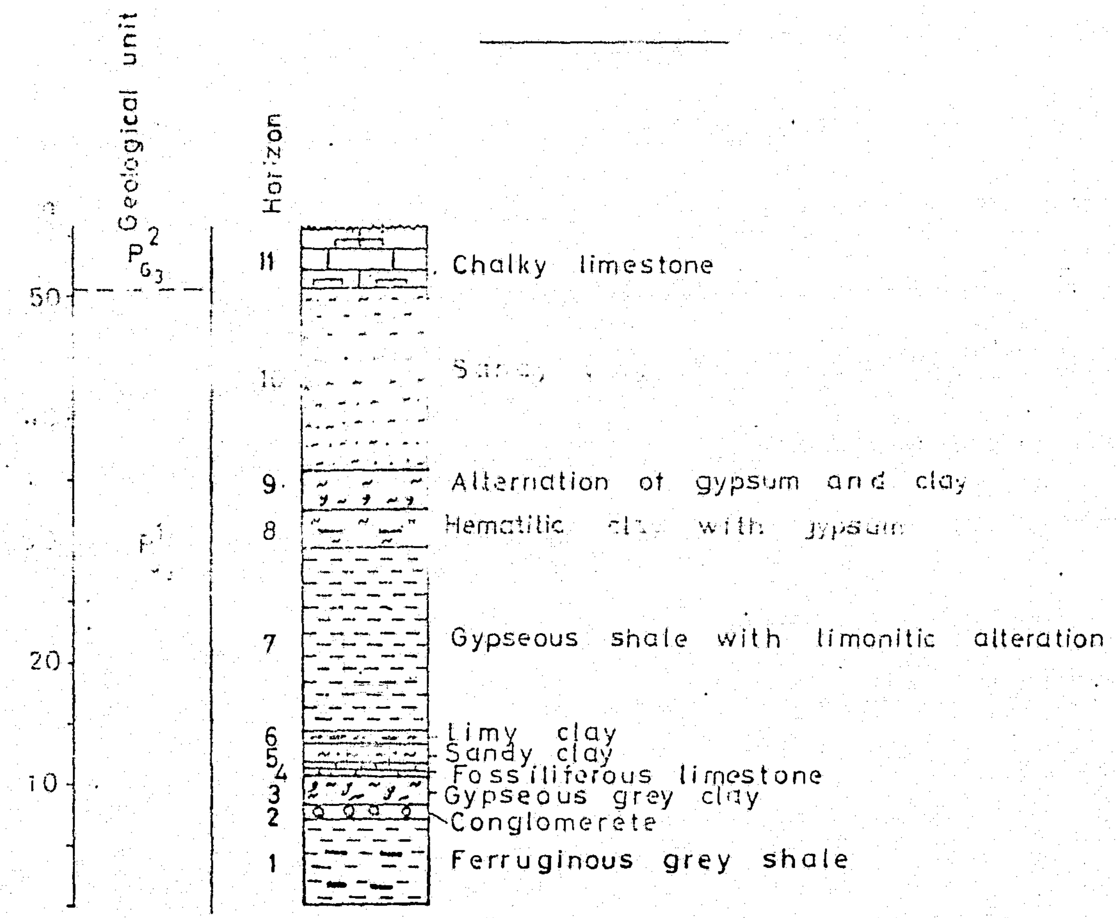
DEIR SAMUEL

LITHOSTRATIGRAPHIC SECTION V



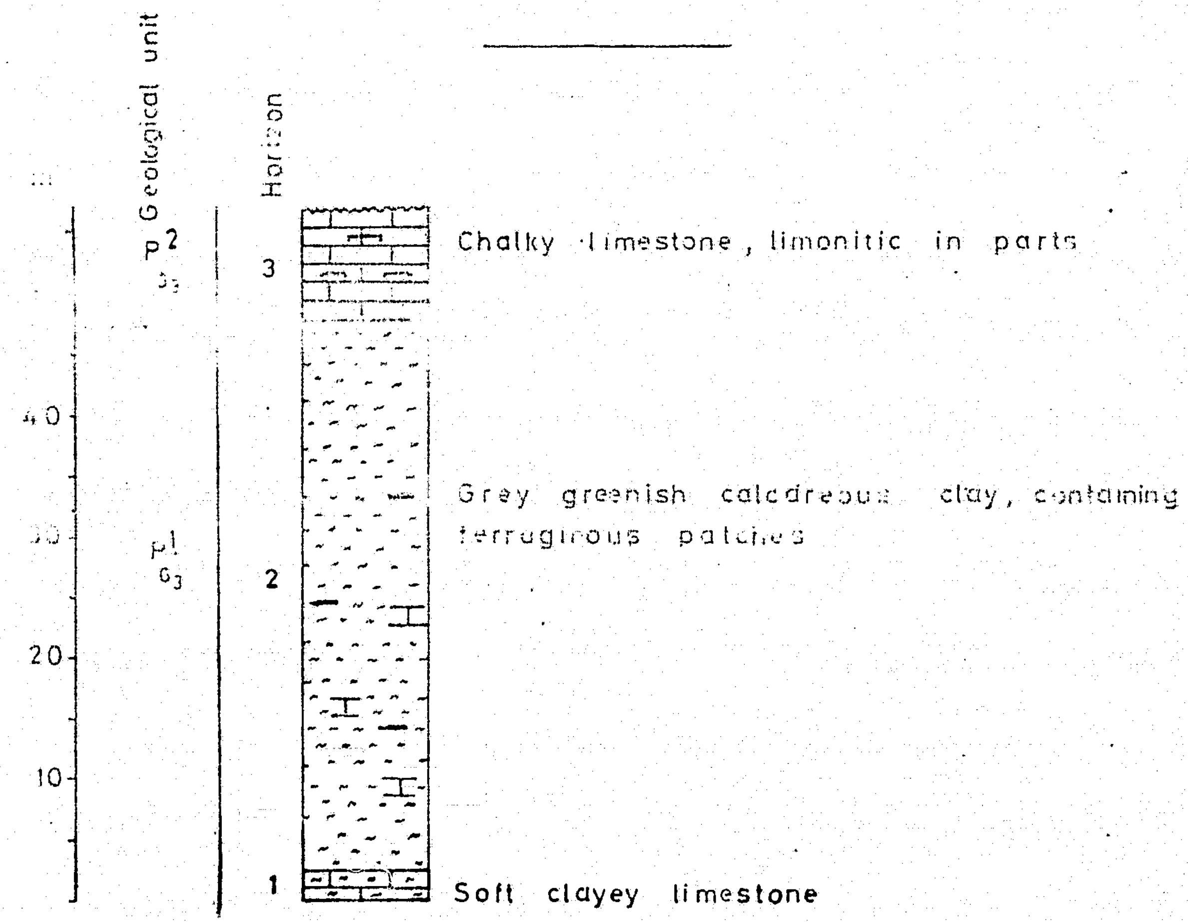
QARET HAD EL BAHR LOCALITY

LITHOSTRATIGRAPHIC SECTION VIII



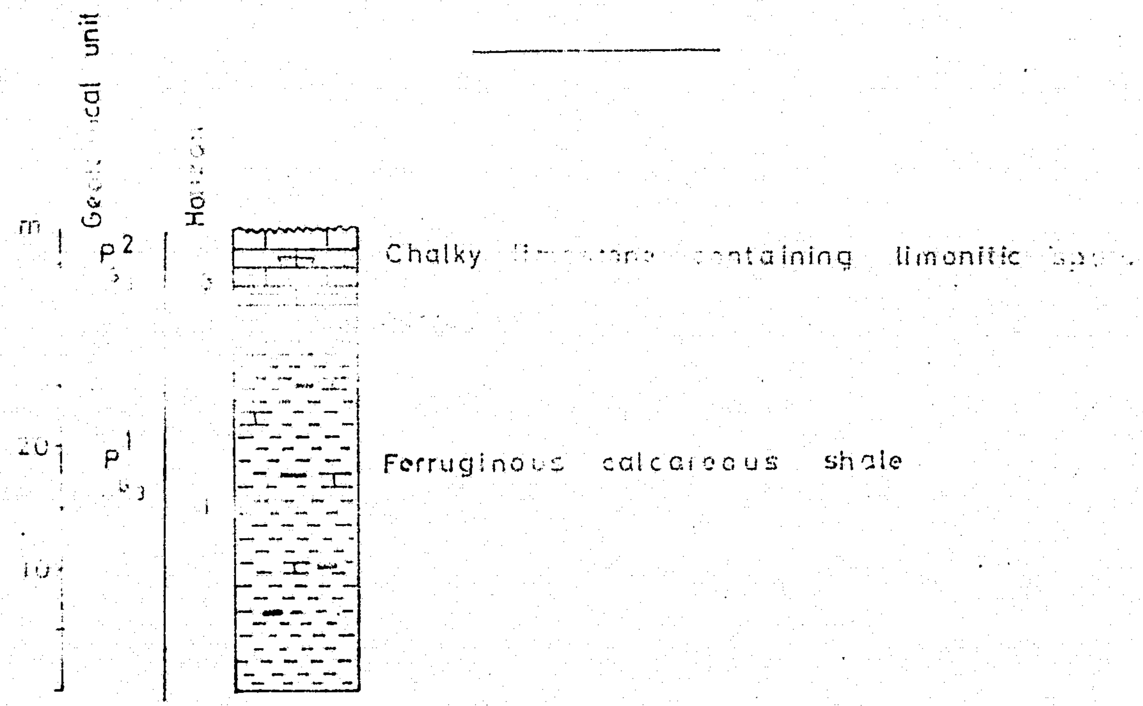
GEBEL QALAMUN

LITHOSTRATIGRAPHIC SECTION XIV



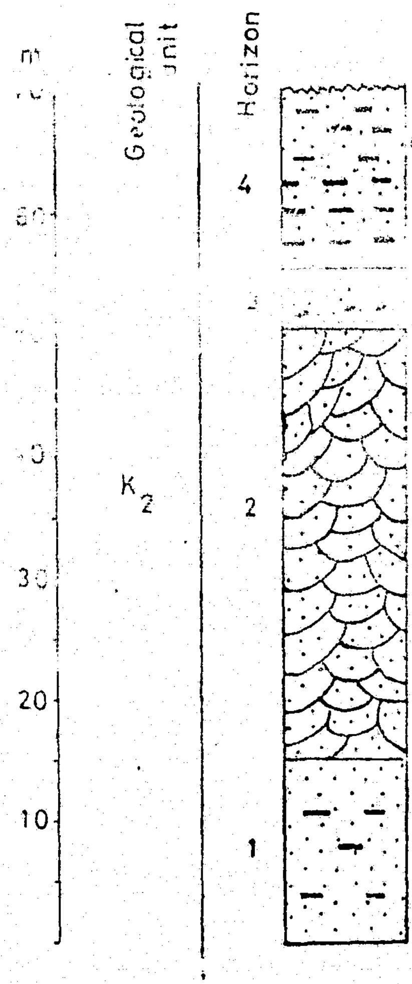
SE DEIR SAMUEL

LITHOSTRATIGRAPHIC SECTION XV



SE DEIR SAMUEL

LITHOSTRATIGRAPHIC SECTION XXX



4 — Ferruginous fine grained sandstone, the nonferruginous rock is buff, patches of gypsum are found on the surface planes, ferrugination increases upwards

3 — [illegible] of [illegible] and white [illegible] of gypsum

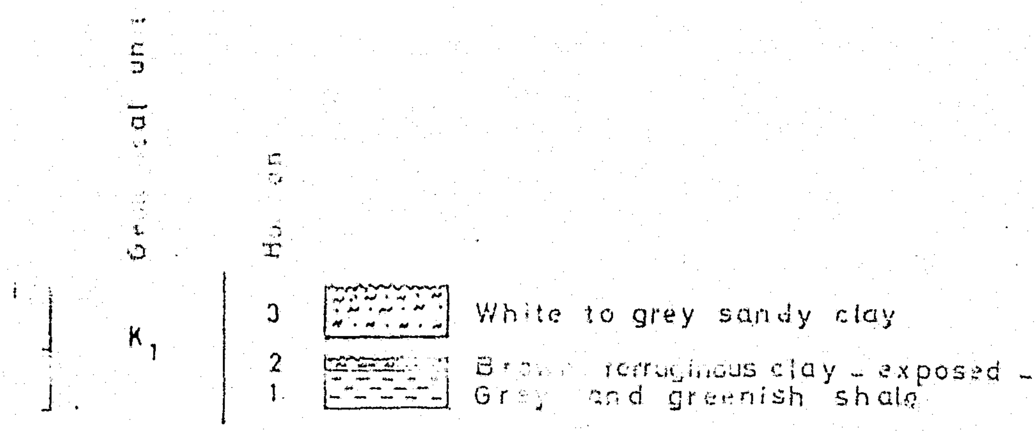
2 — Crossbedded fine grained sandstone, creamy with red iron patches

1 — Pale yellow fine grained sandstone, with thin laminae of iron and manganese oxides

NW AIN EL GHARBIA

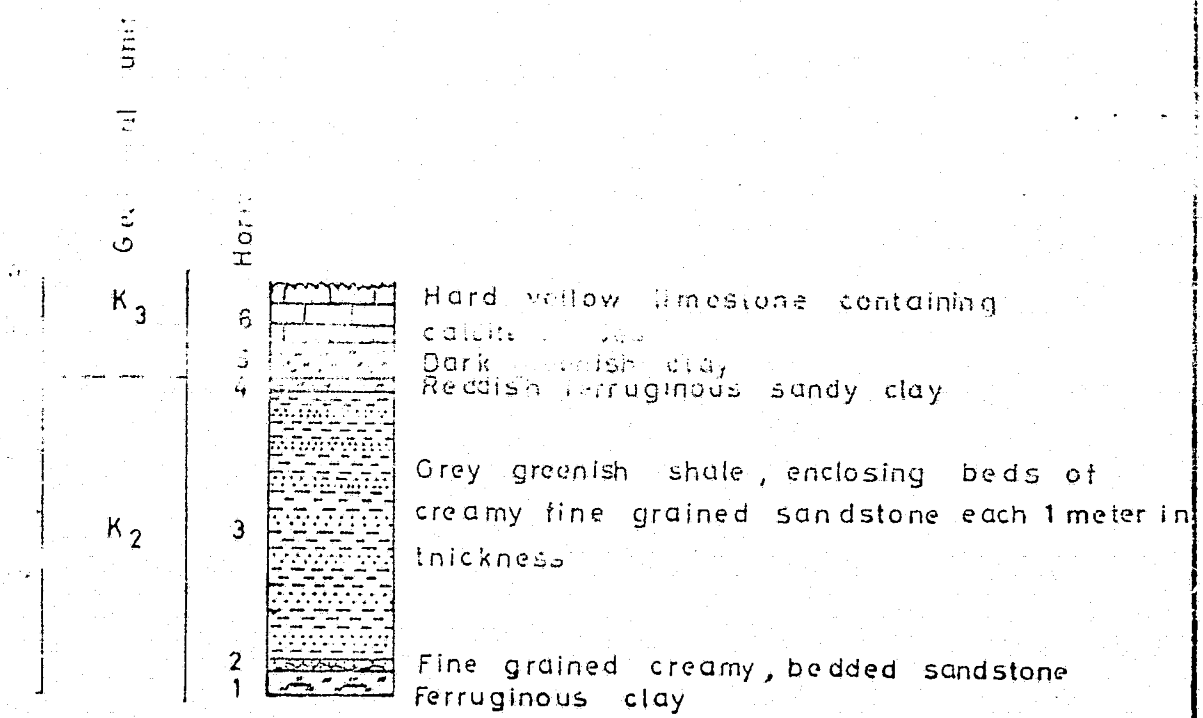
PLATE XXVII

LITHOSTRATIGRAPHIC SECTION XXXI



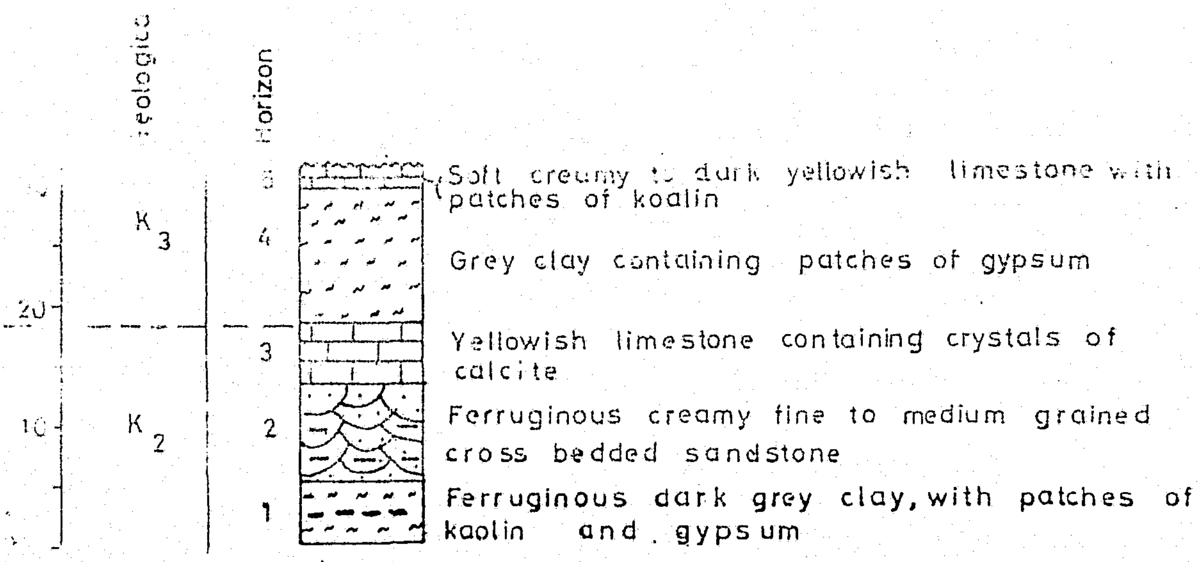
OARET EL SHEIKH

LITHOSTRATIGRAPHIC SECTION XLII



AIN KHOMAN

LITHOSTRATIGRAPHIC SECTION XLIII



NAQB EL SELLIM